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THE SEA BIRDS OF CULEBRA AND ITS ADJACENT ISLANDS, PUERTO RICO

CAMERON B. KEPLER AND ANGELA K. KEPLER

Photographs by the authors

On 27 February 1909, Theodore Roosevelt signed executive order number 1042, declaring all public land in Culebra, including its offshore islands, a preserve for native birds, subject, however, to use for naval and lighthouse purposes. In so doing he set the stage for conflicting use of this newly-acquired prize of the Spanish-American war, and ramifications of his order are only now being resolved. After President Roosevelt's order, the islands were virtually ignored by the U. S. government until the U. S. Navy took them over in 1936, and set up targets for gunnery and bombing practice. This use was formally acknowledged on 14 February 1941, when President Franklin Roosevelt signed a new executive order, again the result of a foreign war, establishing the "Culebra Island Naval Defensive Sea Area" and "Culebra Island Naval Airspace Reservation," a three-mile wide corridor surrounding Culebra, and into which no boat or aircraft could enter without permission from the Secretary of the Navy. The U. S. Navy then began using their new targets, and continued to do so long after World War II.

In the late 1960's political pressure built up against the naval presence and the Navy decided to leave in 1975. In the midst of the controversy, the Navy and U.S. Fish and Wildlife Service jointly agreed to study the islands to determine their natural value; the authors willingly volunteered, and we began our survey with a helicopter overflight on 3 August 1970. From January through June 1971 the U.S. Navy provided us with a Boston whaler, helicopters, ground transport, and, on one occasion, a federal marshal to safely escort us through a throng of militant anti-Navy protestors on Playa Flamenco, many of them bearing flags depicting sea birds destroyed by naval bombs.

Once on the islands, we realized how little was known about them. Although someone's knowledge must have prompted Roosevelt's original order, we have found no writer that mentions seeing a single sea bird nest in the Culebra Islands, although Wetmore (1917) was told of Brown Boobies (*Sula leucogaster*) nesting on two barren rocks (Cayos Geniqui) east of Culebrita. During our August flight we saw gulls and terns on most islands, and we later found 10 species of nesting sea birds, all new breeding records for Culebra; four were new for Puerto Rico as well: Red-billed Tropicbird (*Phaethon aethereus*), Common Tern (*Sterna hirundo*), Royal Tern (*S. maxima*), and Sandwich Tern (*S. sandvicensis*). The colonies of Sandwich Terns were only the second and third known for the Antilles. These colonies were diverse, containing 56 percent of the sea bird species that breed in

Roseate Terns

S. dougallii

the West Indies. The colonies also were extensive; nests were found on 13 of the 17 cays, and on mainland Culebra, where 65,000 pairs of Sooty Terns (*Sterna fuscata*) covered 22 hectares of land within, and adjacent to, a major bombardment area.

Culebra and its Islands

Culebra and its adjacent islands (Figure 1) are centered at 65°18′ W Long., 18°19′ N Lat., 37 kilometers east of Puerto Rico and 25 km west of St. Thomas, Virgin Islands. Culebra is a hilly island of 2,730 ha that rises to 198 meters at Mt. Resaca from a deeply indented shoreline of shallow bays, mangrove swamps, and sweeping crescent beaches (Figure 2). It was first settled by Spaniards in 1880, and in 1970 the population of 900 was largely concentrated near Dewey, at the head of Ensenada Honda. Most of the island is cattle pasture, although Mt. Resaca and its northern slopes are covered by xeric forest that helps isolate, and thus protect, the north coast (Figure 2). Cattle, fishing, and light industry are sources of employment, and some exploitation of nesting sea birds is a local tradition, although undoubtedly hampered in the past by the naval activities.

Culebra rises from the shallow waters of a bank that includes Puerto Rico and the northern Virgin Islands; ocean depths are normally less than 55 meters (Robertson, 1962). Surrounding Culebra are 17 cays and 6 named rocks that are awash in stormy weather (Table 1). The sea bird islands fall naturally into three groups: Cayo de Luis Peña and five cays extending northwest (Western Cays), Peninsula Flamenco and five islands off its northern tip (Peninsula Cays), and Cayo Matojo and five islands to the northeast (Northern Cays). Three cays (Pirata, Pela, Pelaita), not investigated in this study, lie south of Culebra.

For 35 years (1941-1975) the U.S. Navy bombed or strafed Peninsula Flamenco and Cayos del Agua, Alcarraza, Botella, and Culebrita with live and inert ordnance and napalm. This activity has had a significant effect on seabird distribution, both by destroying colonies in impact zones, and, conversely, protecting adjacent areas from other disrupting human activity. The Navy has



Figure 1. Culebra and its adjacent islands, Puerto Rico.



Figure 2. Culebra's north coast, looking east from Punta Flamenco across Playa Resaca and Punta Resaca. Note Cayo Matojo off Punta Resaca, Cayo Norte offshore, and St. Thomas, Virgin Islands in the background.

now left, and we will soon learn which type of disturbance is most deleterious if the important colonies are not rigorously protected.

Climate and Vegetation

Culebra receives easterly trade winds averaging 16 km per hour throughout the year. The variable annual rainfall ranges from 406 to 1,495 millimeters (average 908 mm); nearly half falls from August through November. We could find no temperature data for Culebra but Vieques, 14 km south, has a mean of 27° C, with mean daily maximum and minimum of 31° C and 22° C (U.S. Dept. Interior, 1971). Because of continuous high temperature, large numbers of sunny days, and nearly constant trades, evaporation and transpiration exceed precipitation. The native vegetation is subtropical dry forest (Ewel and Whitmore, 1973). Once almost completely forested, only remnants of the original cover remain.

Methods

We made 13 trips, totalling 23 days, to Culebra and its adjacent islands (Table 2), camping frequently and visiting important areas as often as time and logistics permitted. We censused the entire surface of the smaller islands and selected sections of the three larger ones, recording all birds seen. We mapped or described the geographic location of each colony, described its habitat, and recorded the contents of each nest. We sampled the Sooty Tern colonies by counting the number of eggs and chicks in 10 by 10 foot (3.05 × 3.05 m) plots. In only a few instances could we follow known nests through the breeding season. We were greatly aided on many trips by Bruce Sorrie, and in June by Jacob Valentine; Herb Raffaele contributed notes from a trip to the islands in February 1972.

TABLE 1

Culebra's Adjacent Islands

Island	*Approximate dimensions (meters)*	*Maximum elevation (meters)*	*Distance from Culebra (kilometers)*	*Character*	*Sea-bird use*
Western Cays:					
Cayo de Luis Peña	2,300 × 1,000	145	0.75	Hilly, wooded	Tropicbirds local on shore
Cayo del Agua*	250 × 150	15	2.00	Flat, barren soil	Tern nesting attempts
Cayo Raton	100 × 80	15	2.46	Cliffs, barren rock	Terns throughout
Cayo Yerba	160 × 120	20	2.35	Cliffs, plateau with sedge	Terns throughout
El Mono	—	<5	3.95	Barren rocks awash	Roosting in calm weather
Cayo Lobo	850 × 450	40	4.45	Cliffs, hills w/woods & scrub	Few tropicbirds, terns, on cliffs
Cayo Lobito	230 × 180	25	5.15	Cliffs, plateau w/dense scrub	High larid diversity
Peninsula Cays:					
Cayo Flamenco	180 × 90	10	0.03	Cliffs, plateau w/scrub	Tropicbirds, terns throughout
Cayos Molinos (west)	120 × 90	15	0.15	Cliffs, barren slopes, scrub	Tropicbirds, terns throughout
Piedra Stevens	90 × 50	5	1.03	Cliffs, awash in storms	Roost, some terns may breed
Los Gemelos	40 × 40	10	2.05	Cliffs, awash in storms	Roost, some terns may breed
Alcarraza*	250 × 180	35	2.80	Cliffs, domed, barren	Roost
Northern Cays:					
Cayo Matojo	210 × 130	10	0.08	Low cliffs, plateau w/scrub	High larid diversity
Cayo Norte	2,350 × 950	100	1.01	Hilly, northern cliffs, wooded	Tropicbirds local on cliffs
Cayo Sombrerito	150 × 100	15	2.11	Cliffs, plateau w/dense scrub	Larids throughout
Cayo Ballena	40 × 30	<5	3.52	Rocks awash	Roost
Cayo Tiburón	100 × 50	10	3.18	Rocks awash	Roost
Cayos Geniqui:					
north cay	230 × 170	20	2.95	Cliffs, plateau w/sedge	Boobies, larids throughout
south cay	330 × 100	20	3.04	Cliffs, mostly barren rock	Boobies, terns, higher areas
Cayo Botello*	180 × 100	10	1.29	Flat, barren soil	None
Isla Culebrita	1,950 × 1,250	75	1.20	Hill, wooded, eastern cliffs	Tropicbirds local on cliffs
Southern Cays:					
Cayo Pirata	190 × 90	10	0.25	Not examined	None seen from helicopter
Cayo Pela	240 × 120	10	0.31	Flat, w/hill; mangroves	None seen from helicopter
Pelaita	60 × 20	<5	0.27	Flat, mostly bare	None seen from helicopter

* Actively bombed during this study.

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The Western Cays

Cayo de Luis Peña

Luis Peña is the highest and second largest (43 ha) of the offshore islands. Although formerly settled by two families who raised cattle (Danforth, 1935), only a transient crew at a naval observation post inhabited the island in 1971. Although the introduced mammals included a few cattle, one horse, one goat, three dogs, and feral cats and rats, Luis Peña is covered with the least disturbed forest in Culebra.

The only nesting sea birds were White-tailed Tropicbirds *(Phaethon lepturus)*, which nested on the island's extreme edge, one colony (11 nests) near the tip of Punta Cruz, and another (six nests) on the southern edge of the south peninsula. All nests were hidden under coastal boulders (Figure 3), or in caves at the eroded base of the island, and ranged from 3 to 12 meters ($\bar{X}$ = 6 m, SD = 2 m) from the sea's edge, and from 1 to 4 m ($\bar{X}$ = 2 m, SD = 1 m) above sea level. All would be exposed to heavy surf in stormy weather, which must affect colony success in some years; they could not survive in such sites on islands east (windward) of Culebra, where seas are heavier.

Cayo del Agua

This low cay, 700 meters northwest of Luis Peña, consists of a circular, heavily-bombed eastern section, and a less-disturbed western peninsula (Figure 4). Because of the bombing, vegetation is severely limited, but some low shrubs and *Opuntia* cactus survive near the western point. In spite of frequent range use, Bridled Terns (*Sterna anaethetus*) and Sooty Terns attempted to nest in May and June. In May more than 200 Bridled Terns perched around the edges of both island sections, but none used the targeted center, and we found two nests under eastern bushes. In June we found 30 nests (28 eggs, 2 downy chicks) on cliffs on both halves of the island, and estimated that 50 pairs nested.

We found more than 600 Sooty Terns (13 eggs) in May; all nests were on the flat top of the western half of the island, completely separated from *S. anaethetus*. There were no eggs on 12 May (U.S. Navy personnel, pers. commun.), so nesting had just begun. This nesting attempt was unsuccessful, as there was no sign of the colony in June.

Cayo Raton

"Rat Key," a roughly circular island only 600 meters northwest of Cayo del Agua (Figure 4), slopes gradually from the sea on the north, and precipitously on the west and south. The east cliffs, less abrupt, hold some shallow turf between broken rocks, the only soil on the island. The highly fragmented top provides a tenuous foothold for a few trees. We saw freshly broken eggs, and assumed that rats were present, perhaps giving this rocky island its name. In June we found 60 Common Tern nests with eggs (plus 1 chick), all loosely clumped about one-half meter apart in shallow nest scrapes on the east coast, restricted entirely to the turf. We searched the area thoroughly and estimated the total population at about 75 pairs.

In May more than 300 Bridled Terns roosted on the steep cliffs and relatively flat top. The only signs of nesting were four freshly-opened eggs. In June we found only two nests (eggs), although adults flew from four locations on inaccessible cliffs, and we estimated that about 40 pairs were active. The only indica-

Isla Culebra					
Southern Cays:					
Cayo Pirata	190 × 90	10	0.25	Not examined	None seen from helicopter
Cayo Pela	240 × 120	10	0.31	Flat, w/hill; mangroves	
Pelaita	60 × 20	<5	0.27	Flat, mostly bare	None seen from helicopter

• Actively bombed during this study.

TABLE 2

Surveys of Culebra and its Adjacent Islands, 1968–1971

Date	*Time*	*Locations visited*
1-3 October 1968	3 days	Culebra: Monte Resaca, Playa Brava, Laguna del Flamenco, Playa Larga
3 August 1970	08:00-09:10	Helicopter: all islands and coast
4-6 January 1971	3 days	Culebra: Monte Resaca, Playa Resaca
29 January 1971	11:00-16:00	Culebrita, Luis Peña, Peninsula Flamenco
30 January 1971	09:00-16:00	Culebrita
20 February 1971	08:00-18:00	Culebrita
13 March 1971	09:30-16:00	Culebrita, helicopter flight of all islands
14 March 1971	11:30-17:30	Culebrita, Cayos Geniqui
15-16 April 1971	2 days	Culebrita, Cayo Norte (overnight), Cayo Sombrerito
13-14 May 1971	2 days	Cayo de Luis Peña (overnight), del Agua, Raton, Yerba, Lobo, helicopter flight of all islands
1-2 June 1971	2 days	Peninsula Flamenco, Luis Peña, Lobito (Sorrie only)
10-11 June 1971	2 days	Culebrita (overnight), Cayos Geniqui, Matojo, Botella, Tiburon, Ballena
18-20 June 1971	3 days	Peninsula Flamenco (overnight), Cayo Flamenco, Molinos, Piedra Stevens, Los Gemelos, Alcarraza, Luis Peña, del Agua, Raton, Yerba, Lobo (overnight), Lobito

tions of the May colony were several egg fragments; we suspect that rat predation was heavy, and all but the most inaccessible cliff nests were probably destroyed.

In May nearly 50 Brown Noddies (*Anous stolidus*) perched on the northern cliffs and under an overhang and tree near the top of the island; we found five nests (one egg each) and observed one pair copulating, so breeding was just beginning. In June we located 13 pairs (10 eggs, 3 adults on nest sites), mostly on the northeastern cliffs, with a few among boulders above the south coast. The lack of young, which we should have found had the May nests succeeded, again indicated predation.

In addition to the nesting terns, Brown Pelicans (*Pelecanus occidentalis*) roosted on a large tree (much whitewash and a skeleton), and 50 Sooty Terns perched (no nests) on the island in May.

Cayo Yerba

Cayo Yerba, 450 meters north of Cayo Raton, is essentially a smooth plane tilted up about 30° from east to west, and surrounded by crumbly red vertical cliffs (Figure 4). The sloping plateau, easily accessible from the east, is densely covered with a sedge (*Cyperus planifolius*) approximately one meter high, a distinction shared only with the north cay, Cayos Geniqui.

During our August (1970) helicopter overflight we saw one adult Red-billed Tropicbird flying offshore. Although we saw no active nests in 1971, we found rectrices in a typical cliff-face nest site, and assume the species breeds in small numbers.

In May the calls of about 20 Bridled Terns and 200 Brown Noddies resounded all around Yerba's cliffs. No eggs were found, but the noddies were building pebble nests (four pairs) on the cliffs and copulating (one pair). In June the Bridled Terns defended 13 nests (1 egg, 2 chicks, 10 contents not seen), and another 12 pairs probably had eggs or chicks in hidden crevices. We counted 87 noddy nests, all on crumbly ledges, and estimated 100 breeding pairs.

It was not these cliff-nesters, however, that attracted the eye, but the Sooty Terns that dominated the plateau. From our camp site at dawn on Luis Peña (14 May), we were dazzled by a dense cloud of them over Yerba; thousands were leaving the island from their nocturnal massing, and half were gone before 08:00. We later found about 5,000 adults remaining on the plateau, where they ran through the *Cyperus* with ease on a labyrinth of hidden trails. We found 20 eggs in a swath 25 by 10 meters, and estimated that several hundred had been laid.

In June, eggs, chicks, shells, and rings of guano covered the plateau, and we sampled them in 10 grids, each measuring 10 by 10 feet, five plots each on the east (low) and west (high) sides. From these counts we made two calculations of the breeding population. A low estimate included only definite evidence of nesting, such as eggs, chicks, and egg shells (if the latter exceeded the number of chicks in each plot; in this way nests from which chicks had wandered were not counted twice). The result, 6.6 per 100 square feet, is an estimate of the breeding population active at or near the time of the count. Many eggs and egg-shells, however, were surrounded by a ring of guano, and many such rings lacked eggs or chicks; we assume they represented failed nesting attempts (according to local residents, Sooty Tern eggs collected from offshore cays were often sold in Culebra). Adding these guano rings to the number of eggs and shell fragments should give an estimate of the maximum breeding population. With one exception, numbers consistently ranged from 12 to 17 per plot ($\overline{X} = 14.3$).

The entire plateau, an area of approximately 11.6 ha, was covered by nesting Sooty Terns. Thus, about 8,300 pairs were active during our visit, and as many as 18,000 pairs may have attempted to breed; the latter figure appears reliable in view of the swarm of birds over the island in May. What happened to the other 10,000 pairs? We suspect that eggs from most of them were taken for human consumption. The colony is most accessible from the east, and we found



Figure 3. Boulder beach on south coast of Cayo de Luis Peña favored as a nesting area by White-tailed Tropicbirds, with Punta Cruz, location of another tropicbird colony, behind. Cayo Lobo shows prominently on the horizon.

fewer eggs, far fewer chicks, and more broken egg shells on that side of the island (it is hard to walk without stepping on hidden eggs). If non-human predation or natural losses were operating, we would expect roughly equal impact on both sides of the island.

El Mono

These low rocks are awash in stormy weather, and held no breeding sea birds during the study.

Cayo Lobo

Roughly cross shaped (Figure 5), Cayo Lobo is the fourth largest of Culebra's islands. Recumbent, windswept vegetation, punctuated at intervals by stark clumps of dildo cactus (*Cephalocereus royenii*), dominated the island, although a small patch of xeric forest hugged the sheltered west-central coast and adjacent leeward cliff shelves. Rats, unfortunately, have invaded the island, and since our study the island has been heavily bombed (Tom Carr, pers. commun.).

Lobo was not an important sea bird island, in spite of many flat areas with low vegetation and several hundred meters of excellent cliffs, some of them 30 meters high. Red-billed Tropicbirds, however, and probably White-tailed Tropicbirds, bred in small numbers. Two adults of the former species circled gracefully offshore in May, and five repeated the performance and landed on the northwest point in February 1972 (H. Raffaele, pers. commun.). We found one downy young on the west (leeward) side of this peninsula, about eight meters above sea level, in a cavity under large boulders in a rough, broken



Figure 4. Looking northwest to (right to left) Cayo del Agua, Cayo Yerba, and Cayo Raton, with Alcarraza in the background. Note the target on Cayo del Agua.

section of cliff. Five weeks later the chick was in juvenal plumage, and another adult occupied a nearby cavity. Two additional sites contained shell fragments belonging to either *P. aethereus* or *P. lepturus*. The cliffs are extensive, and we estimated that as many as 10 pairs may breed.

The only White-tailed Tropicbirds seen were five adults in courtship flight off the northwest peninsula in June, and an adult roosting in a nest site similar to those of *P. aethereus*; we found two additional nest sites containing tail feathers.

Ten or so Bridled Terns flew over Lobo in August 1970; no birds were present in May, but on 20 June we found four nests with eggs on windward cliffs. There were no concentrations of adults anywhere that indicated extensive nesting, so we estimate that as few as five pairs bred in 1971.

Cayo Lobito

Cayo Lobito, the terminal western cay, is the most remote of Culebra's islands. From above it resembles a fat hourglass, with its plateau, 25 meters high, surrounded by steep cliffs, except where a narrow southern beach gradually slopes up to it. This plateau is densely vegetated; plants are low and creeping to the east, but gradually increase in height toward the western cliffs, where they form a dense mat about one meter high (Figure 6). A flat, surf-washed shelf surmounted by a barren stack (10 m high) extends about 100 meters south of the main island. We found nests of four species on Lobito, and assume that Red-billed Tropicbirds bred, for two adults cruised the plateau's south point and the south stack during our June visit.

Laughing Gulls (*Larus atricilla*) were the most conspicuous birds on the island; we saw them from the helicopter in August 1970, and nearly 1,000 adults, probably representing about 450 breeding pairs, mantled the plateau in June. We found 66 nests, all on the periphery of the south and east coasts, and always



Figure 5. Looking northwest at Cayo Lobo, with Alcarraza in the background.

in low vegetation, or near slight openings or projecting rocks. Several were near the Royal/Sandwich Tern colonies, one only 30 centimeters from the nearest tern egg. The general locations of large numbers of uncounted nests were indicated by adults that took flight ahead of us as we searched the plateau. Most nests held eggs, and those with one egg were the most common (22, versus 14 with two, and 10 with three eggs), perhaps because many chicks had hatched and hidden under dense surrounding vegetation. Four nests held both eggs and downy young, and three had young only.

About 30 pairs of Bridled Terns nested on the cliffs of the main island and on the detached southern stack; we found one egg and one chick. Nearly 100 Sooty Terns roosted on the island, but we found no evidence that they nested.

Royal and Sandwich Terns nested compactly in five colonies on the exposed northeastern top of the plateau. Sandwich Terns far outnumbered Royals, which were visible as conspicuous flashes of red among a sea of yellow-tipped black bills. All nests were unlined scrapes on bare soil (Figure 7). Sorrie discovered the birds incubating at pecking distance from each other on 1 June. By the 19th, dozens of eggs had pipped, particularly in the largest colony (Table 3), and downy chicks lay huddled in their nest scrapes. Laying was highly synchronous, with a majority of the eggs (422 of 805) in a single colony a few meters from four smaller sub-colonies. We estimated the breeding populations at 120 Royal Terns and 700 Sandwich Terns.

The Peninsula Cays

Peninsula Flamenco

Peninsula Flamenco, part of the western bulwark of Culebra, extends 3.2 km from Playa Flamenco, its scenic connection to the rest of the island. Its tip lies 6.5 km from Dewey, and because of its prominent profile (0 to 115 m) and iso-

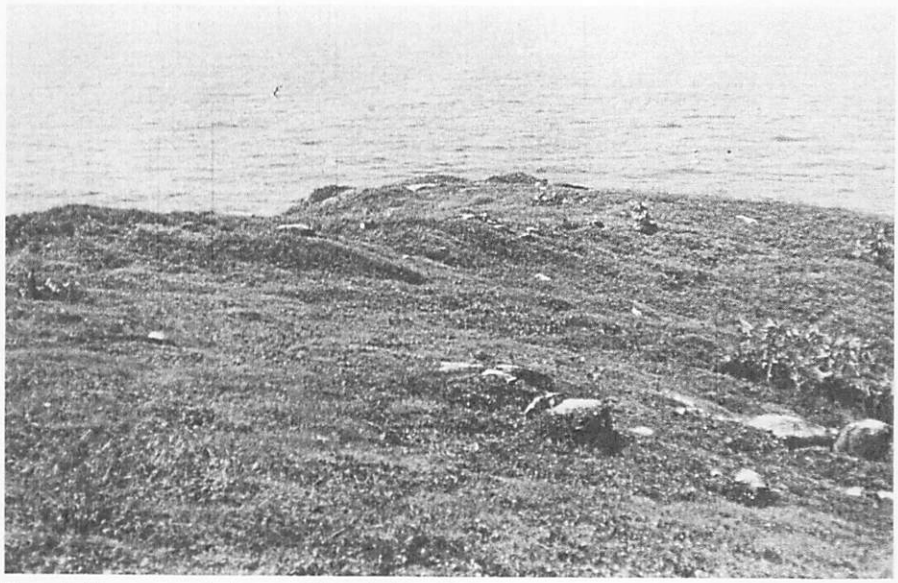


Figure 6. The vegetated plateau of Cayo Lobito, looking east toward the Royal and Sandwich Tern colonies (~~arrow~~).

lation from humanity, was an important impact area for naval bombardment. The point is marked with craters, and fires have destroyed all but remnant patches of the original forest, leaving in their wake a dense cover of guinea grass (*Panicum maximum*) to which cattle frequently strayed. Two unnamed islands lie close offshore: we have called the westernmost, barely 30 meters from the mainland, Cayo Flamenco, and its neighbor, 300 meters east, Cayos Molinos, after Punta de Molinos, the peninsula's easternmost projection (Figure 8).

From our May campsite on Luis Peña we observed a tremendous buildup in Sooty Terns over Peninsula Flamenco as night approached: at dusk tens of thousands of birds formed an opaque cloud. Greatly reduced numbers remained during the next day. When Sorrie surveyed the peninsula on 1 and 2 June, he estimated about 100,000 birds, and egg-laying had begun. We censused the colony on 18 June and divided it into three geographic areas (Figure 9).

1. *Northwest tip.* This finger of land, extending 305 meters northwest from the main peninsula, rises gently from a rocky eastern beach and ends abruptly in 15-meter cliffs on the west. Sea-grape (*Coccoloba uvifera*) overgrown with morning-glory (*Ipomoea* sp.) dominates the eastern slopes below a dirt road to the point; above the road open grassy meadows alternate with forest patches. The road served as a boundary for three study areas (Table 4). Constantly swept by trade winds, the outer point beyond the road, a mosaic of guinea grass clearings and brush one to two meters tall, held the greatest tern densities on the peninsula. Continuous with this, the main colony extended 300 meters southeast, with birds concentrated under two- to four-meter-high vegetation nearest the cliffs. These two areas held 39 percent of all nests (25,600) in 16 percent of the colony area. An additional 500 pairs nested under the *Coccoloba* below the road.

2. *Northern swale.* The rocky beach between the two northern points extends south as a broad guinea-grass-covered swale that narrows gradually as it rises to the common ridge 40 meters above sea level. Here Sooty Tern nests were extremely dispersed, and the number of eggs in our plots, placed 100 feet (30.5 m) apart in two parallel compass lines, varied from zero to two. As the transects cleared

TABLE 3

Royal Terns (*Sterna maxima*) and Sandwich Terns (*S. sandvicensis*) on Culebra's Adjacent Islands, 1971

Location	*Date*	*S. maximus*			*S. sandvicensis*		
		Eggs	*Young*	*Total nests*	*Eggs*	*Young*	*Total nests*
Cayo Lobito							
Colony I	19 June	3	0	3	122	0	122
Colony II	"	46+	0	46+	73	0	73
Colony III	"	9	0	9	67	0	67
Colony IV	"	27	few	27+	274	121*	395*
Colony V	"	21	0	21	42	0	42
Total	"	106+	few	106+	578	121*	699*
Cayo Matojo							
East Colonies	11 June	32	0	32	2	0	2
West Colonies:							
I	"	0	0	0	2	5	7
II	"	0	0	0	11	0	11
III	"	2	0	2	5	0	5
Total	"	34	0	34	20	5	25

* A small number of *S. maximus* young were included in the *S. sandvicensis* totals.

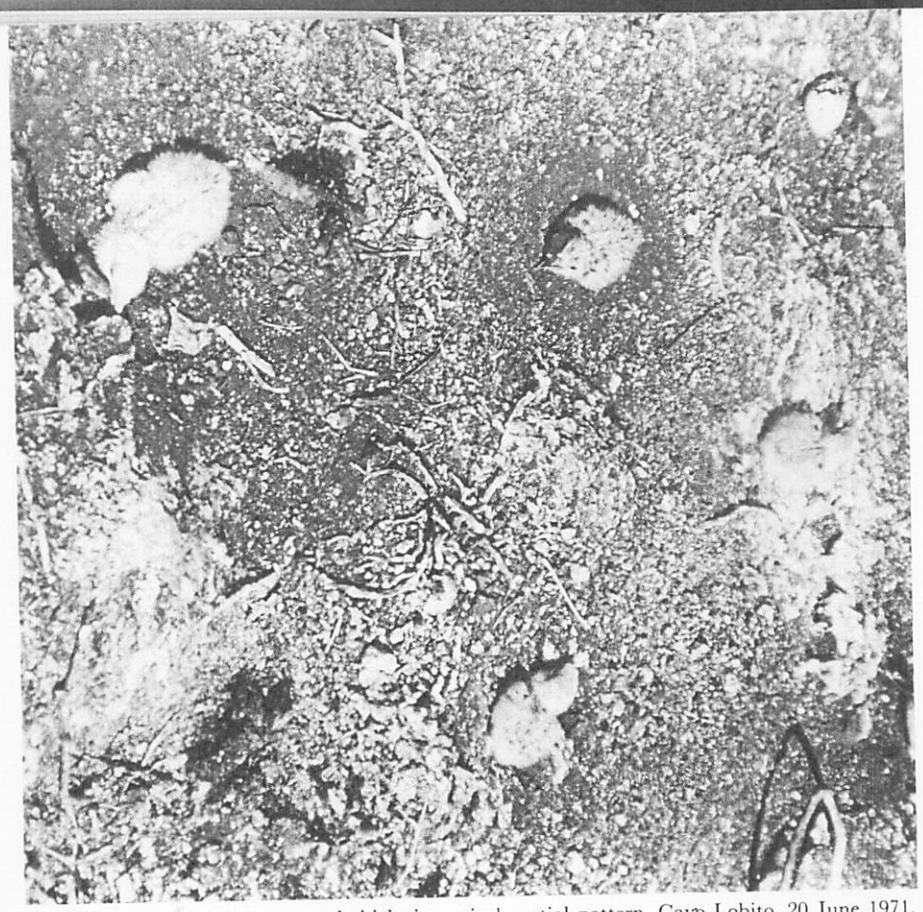


Figure 7. Sandwich Tern eggs and chicks in typical spatial pattern, Cayo Lobito, 20 June 1971. The figure has been turned 90° clockwise. View it from the outer edge of the page.

Punta de Molinos ridge, however, the grass thinned, scattered rocks appeared, the trades provided relief from the swale's heat and humidity, and nest density increased 500 percent (Table 4).

3. *Main peninsula.* South of the swale, the hills are broad and relatively flat above 25 meters and rise gradually to an exposed, rocky western ridge, where they drop steeply to the sea. The road paralleled the ridge about 45 meters to the east, and formed a boundary between segments of the colony that extended south from the swale along both sides for 365 meters. Sooty Terns nested most abundantly (3.5 eggs per plot) east of the road, where wind-swept guinea grass was only about one meter high, and along the windward side of the ridge, although they avoided bare areas. Nest density decreased considerably on the lee slopes, where low wind, high temperatures, and high humidity favored a lush grassy carpet. The colony ended abruptly 75 meters below the ridge (Table 4).

In 1971 Sooty Terns covered 18 ha of the peninsula, extending 825 meters south from the northwest tip. Greatest concentrations occurred under remnant forest patches where birds could take off easily. Reduced numbers were in windy sites with some vegetation; very low densities were in dense guinea grass meadows protected from the wind. Nests were not found on bare sites on Peninsula Flamenco or any offshore cays, in sharp contrast to other colonies in Puerto Rico (Kepler, ~~in press~~ 1973) or elsewhere in the world (Ashmole, 1963; Robertson, 1964). These observed variations in density may result from habitat preferences or different stresses on segments of the population. The primary sources of stress included naval bombardment, predation by introduced mammals (cats, dogs, rats), human predation, and trampling or disturbance by cattle and goats.

From 13 to 17 June 1971 the navy bombarded Peninsula Flamenco. We examined two impact craters, each about six meters across, in the densest population on the northwest tip, and examined another 50 to 100 craters in the main peninsula colony (Table 4, Area 3). Each of the latter craters destroyed 15 to 20 nests, so as many as 2,000 nests (3%) could have been affected by a five-day naval exercise. In general, impact craters in the densest tern areas were rare, as the northwest tip is out of sight from the observation post, and thus not targeted. Most craters were restricted to Punta de Molinos and areas south, and the damage we saw resulted from unusually large ordnance. We estimate that annual mortality from naval use would be between five and ten percent of eggs laid.

In the impact zone we found piles of freshly-killed adult Sooty Terns, their breasts, heads, and entrails eaten, that resembled a description of rat larders (Austin, 1948); we suspect that rats and/or cats ate birds damaged or killed during range use. Cat predation on healthy birds is likely, though we have no evidence for it. All signs of predation were in areas proximal to Culebra proper.

We never saw Culebrans taking eggs, but residents in Dewey openly reported that Sooty Tern eggs were a delicacy. Tom Carr (pers. commun.), during extensive turtle studies on Culebra, saw residents carrying sacks of eggs from Peninsula Flamenco in 1976, and was told in 1974 that eggs taken from the peninsula and small offshore cays were openly sold in Dewey in spite of their legal protection. Regular harvesting could result in the relatively low nest densities throughout the area and the absence of any successful nests in locations without cover. Egg-taking would be severely curtailed during active range use.

Cattle rarely reached Peninsula Flamenco in 1971, and there were no signs of grazing within the colony. Carr reports, however, that in 1976 cattle covered the peninsula in high densities, except for the northwest point, which was fenced at its base to exclude them. Sooty Terns were thus restricted entirely to this area, a mere 16 percent of that occupied in 1971. Former colony areas were barren and eroding, or covered with dense thickets of milkweed (*Asclepias curassavica*) or hurricane grass (*Andropogon ischaemum*) that cattle did not eat.



Figure 8. Looking west at the northeastern tip of Peninsula Flamenco, Culebra, with Cayos Molinos and Cayo Flamenco offshore, and Cayo de Luis Peña on the upper left. Vieques shows as a low, irregular profile on the horizon.

TABLE 4

Sooty Tern Census Results for Peninsula Flamenco, Culebra, 18 June, 1971 *

Location	*Predominant vegetation*	*Approximate dimensions (feet)*	*Area (feet² x 100)*	*Number of plots*	*$\bar{X}$ nests per 100 feet²*	*Estimated population*
1. Northwest tip						
a. Outer point	Grass & shrub	150 × 50	75	8	13.4	1,000
b. Main colony	Xeric forest & grass	1,000 × 300	3,000	10	8.2	24,600
c. Eastern slope	*Coccoloba-Ipomoea*	200 × 60	120	2	4.0	500
2. Northern swale						
a. Swale	Tall guinea grass	800 × 450	3,600	14	0.85	3,100
b. Punta de Molinos Ridge	Low guinea grass	360 × 200	720	4	4.5	3,200
3. Main peninsula						
a. East of road	Dense guinea grass	1,200 × 600	7,200	6	3.5	25,200
b. Ridge west of road	Low grass	1,200 × 150	1,800	15	2.5	4,500
c. Lee slope west of ridge	Dense guinea grass	1,200 × 250	3,000	12	1.0	3,000
Colony totals			19,515	71	—	65,100

* Original measurements (feet) are retained for ease of conversion from plot counts (n/100 ft.²) to population estimates.

Nests/pairs

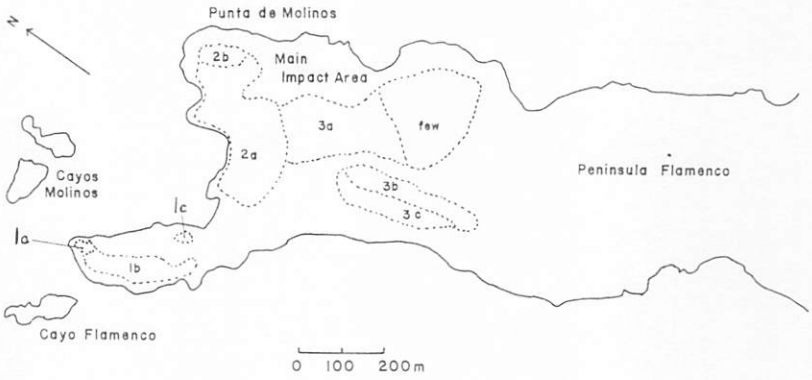


Figure 9. Peninsula Flamenco, with distribution of nesting Sooty Terns, June 1971. Areas correspond to those listed in Table 4 and discussed in the text.

It is important to note that this large colony had not been reported before our visit, and may not have existed before naval use. Although bombardment did destroy habitat and birds, the regular closure of Peninsula Flamenco discouraged egging and grazing, and probably f·vored tern colonization. With the Navy now gone, most the colony has disappeared within two seasons, and the remainder is protected only by a few strands of barbed wire.

Cayo Flamenco

Small and officially unnamed, a former piece of Peninsula Flamenco lies 30 meters west of the headland's tip. Its crumbly cliffs are poor nest sites, and the only tree clutches the base of the southern cliff. The flat, narrow top is covered with dense *Coccoloba* and other bushes less than one meter high.

The species that bred on Cayo Flamenco in June were the normal cliff-nesters and small numbers of Sooty Terns. A pair of White-tailed Tropicbirds circled the cliffs and landed together in a deep crack, but we saw no eggs or young. We estimated 15 breeding pairs of Bridled Terns and found nine nests (eggs), eight of them on cliff faces, one under the south tree just three meters above water level. Of 25 pairs of Brown Noddies, 20 had nests near the top of the eastern cliff. Contents could be seen in 10 of these; they held seven eggs and three downy chicks (one black, two white). Nearly 75 pairs of Sooty Terns nested under the *Coccoloba;* 54 nests contained 33 eggs and 21 downy chicks less than five days old.

Cayos Molinos

Unlike the other islands, Molinos and its neighbors, Los Gemelos and Piedra Stevens, are composed of sharp, highly eroded limestone, with undercut cliffs on most sides. Molinos' western cay slopes up gradually from the south coast, where fallen cliff fragments provide access. Windswept grass and small *Coccoloba* shrubs partially conceal numerous small caves and cracks in the steep, crumbly south-central ridge. Five species bred in 1971, relying heavily on *Coccoloba* and discontinuities along the southern fracture. The low eastern cay was not used.

We found one adult Red-billed Tropicbird in a small hole near the island's top, and three caves with feathers and nest scrapes. We estimate a breeding population of five pairs.

Four species of terns bred. About 250 pairs of Common Terns covered the bare southeast corner of the island; 75 nests examined held eggs (61) and downy young (14). Under the *Coccoloba* near the south cliffs, about 40 pairs of Bridled Terns had eggs and downy chicks and, above them near the top, but still under cover, were about 500 Sooty Tern nests with eggs. Nearly 150 pairs of Brown Noddies remained apart from other species on the cliff faces or in small caves; all 52 nests found contained single eggs.

Piedra Stevens and Los Gemelos

These similar islands are treated together: both are upraised limestone, with little vegetation near the top, and are only five to ten meters high, respectively. We were unable to land, although we circled them closely by boat on 19 June, and flew over them several times.

Brown Noddies and Bridled Terns were closely associated with each island and may breed, as they do on similar islands in La Cordillera, 18 km to the west.

Alcarraza

This massive red dome is the largest and most remote of the peninsula cays. It had been bombed for decades, and was devoid of vegetation in 1971.

Brown Noddies roosted or flew by it in August 1970, and were roosting again when we surveyed the island by boat on 19 June 1971. In addition we saw about 25 Bridled Terns, two Red-billed Tropicbirds, one Laughing Gull, and a Brown Booby. Because of the intensive bombardment, successful nesting was unlikely in 1971, but the cliff-nesting species should quickly recolonize the island now that the Navy has left.

The Northern Cays

Cayo Matojo

Although only 80 meters north of Punta Resaca, this low island shows few signs of disturbance, protected as it is by the north coast's isolation (Figure 2). Cayo Matojo's flat plateau caps a broken line of boulders and sloping soil that reaches up from surf-worn rocks. The island is sparsely covered with wind-pruned grass and *Coccoloba*, throughout which about 80 pairs of Laughing Gulls nested in June. Of 19 nests examined, 18 held only eggs (five with one, eight with two, and five with three) and one held eggs and the only young (downy) seen on the island. Although about 12 Bridled Terns roosted on leeward cliff edges and appeared to breed, we found no nests.

During the August helicopter flight we had noticed roosting Royal Terns on Matojo, and were anxious to look for nests; ten months later we found 32 eggs in several small colonies fully exposed to the trades. We were surprised, however, to find an equal number (25) of Sandwich Tern nests; two pure colonies were located opposite the Royals above the leeward cliffs (13 eggs, five downy chicks), and another seven eggs were mixed with those of the Royals. Matojo birds bred synchronously with those on Lobito (Table 3) and, like them, nested in unlined scrapes about 30 cm apart.

Cayo Norte

Cayo Norte, the largest offshore island, parallels Culebra's northeast coast for 2.3 km (Figure 2). Seaward (northern) cliffs rise precipitously from the surf, in sharp contrast to the gentle sandy beaches to the south; between these coasts the island is covered with a dense but overgrazed (by goats) xeric forest.

Like Luis Peña, Cayo Norte is not a sea bird island, and only Red-billed Tropicbirds attempted to breed in 1971; in April we found about 10 adults soaring past the northeastern cliffs, and two landed in an area with many small crevices. We found one adult at a nest devoid of eggs or chicks. Many cliff areas were available, and large numbers may attempt to breed each year, unless deterred by introduced rats. Our estimate of 10 nesting pairs may be conservative, although we hiked about 65 percent of the north coast without seeing any more adults.

Cayo Sombrerito

Sombrerito, a satellite of Cayo Norte, is essentially a dome of 15-meter cliffs surmounted by a densely vegetated flat plateau (Figure 10). Wind-sheared plants to the east gradually give way to more robust specimens reaching two meters in height on the west, and all are interspersed with about 15 conspicuous clumps of *Cephalocereus*. We landed on 16 April, but were too early for nesting sea birds; and in June the sea was rough, so we could only circle the island by boat. However, in August 1970 we had seen about 50 adult and flying juvenile Laughing Gulls during our helicopter reconnaissance, and they flew from well-spaced locations characteristic of other colonies. The gulls were back in June, and we estimate that about 25 pairs nested.

About 20 Bridled Terns and 20 Brown Noddies flew from the cliffs in August; small numbers perched there again in June, with noddies outnumbering the smaller terns, 2:1. We assume that at least five to ten pairs of each species must have bred.

Cayo Tiburon and Cayo Ballena

Both these islands are surf-scoured volcanic rock awash in stormy weather; we did not land, as it appeared during four helicopter overflights and a boat trip that breeding was unlikely. Because of their isolation more than one km northeast of Cayo Norte, they are important sea bird roosts; we found Brown Boobies (35), a Magnificent Frigatebird (*Fregata magnificens*), Laughing Gulls, Common Terns, Bridled Terns, Royal Terns, and Sandwich Terns in June.

Cayos Geniqui

Two islets connected by a long (100 m) rocky shelf broken by surge channels rise above the sea east of Cayo Norte (Figure 11). They appear vastly different from one another. The south cay is bedrock, except for a small pocket of soil on the lee of the topmost rocks in which a few figs (*Ficus citrifolia*) cling precariously. Both the south and north ends are washed by the highest winter storms, and most sea birds nest on the island's higher middle third. We searched intensively for burrow-nesters in the innumerable cracks and crevices, but found none. We did locate fragments from three fresh bombs.

The north cay is round rather than long, has nearly vertical 20-meter cliffs on all but the southwest side, and is sandstone overlaying bedrock. The



Figure 10. Looking east from Cayo Norte's cliffs (foreground) to Cayo Sombrerito, Cayos Geniqui, and St. Thomas, Virgin Islands.

plateau angles smoothly downward on the southwest to within about five meters of the sea, providing access to the top. This leeward plateau is covered with sedge (*Cyperus planifolius*), as on Cayo Yerba, that thins as it approaches bare northeastern cliffs. Impressive clumps of *Cephalocereus royenii* cluster behind the cliffs, where the downward sloping plateau shelters them from the trades. We explored both islets in March and June.

A colony of Brown Boobies was reported from Cayos Geniqui in 1912 (Wetmore, 1917), but was not investigated until our study. We found resident birds on every aerial or ground survey. They nested in *Cyperus* on the north cay (10 in March, 5 in June), and along the barren edge of the northeastern cliffs. The south cay nests were placed under or near the *Ficus* (all active nests in June), or further down the leeward slopes (13 in March). We found only one nest (March) on the windward cliffs, a precipitous area with few potential nest sites that is a major roosting location (100 birds in June).

On each trip to Cayos Geniqui we tallied every booby nest in one of six mutually exclusive stages (Figure 12). The estimated age of each is based upon descriptions in Dorward (1962). This technique is reliable for determining egg-laying periods in sea birds with prolonged breeding seasons (Kepler, in press). In March, the Brown Boobies were the only species breeding. There were 47 nests, most with eggs (68%) or very young chicks. In addition, there were 18 pairs on territory and three flying juveniles. We found substantially the same stages in June; of 34 nests, 24 (71%) had eggs, and only four nests held older chicks, far less than expected had all the March eggs hatched and survived; 28 young were missing (Figure 12). We heard persistent rumors that local fishermen took young for food and bait, and during this period learned that 20 Brown Booby chicks were taken to Fajardo, Puerto Rico, 40 km away. We suspect that the inordinately high mortality (88%) resulted from human predation.

We found 45 Laughing Gull nests in June; 40 were placed on the north

cay in partial shade, usually near the sedge border close to the island's top. One nest contained a single downy young, the others held eggs (18 with three, 18 with two, and five with one) or were empty (three fresh nests); the stages were synchronous with other colonies.

We saw no terns on Cayos Geniqui in March, but many roosted on the island in August 1970. In June 1971, however, three species were common on both islands. We found about 140 pairs of Bridled Terns, equally divided between the two cays, but in extensive searches we located only 11 nests; 10 held a single egg, one a downy chick. Two nests were located on the cliffs at the south tip of the north cay; the other nine were found from four meters above sea level to near the top of the south cay in shaded locations in rock scree or holes in cliffs. They were never in open, exposed sites, and were widely spaced over the western half of the island. Although about 20 Sooty Terns roosted on the flat top of the north cay, we found no eggs, but suspect a few pairs may nest there, since the habitat is similar to that on Cayo Lobo and Peninsula Flamenco. The Brown Noddy, common on both cays, nested in a wide variety of situations. In June we found 95 nests, 77 on the north cay in open areas, ledges, piles of pebbles, and in trees, where we found two occupied stick nests, the only tree-nesting noddies we saw. Most pairs had a single egg (85), but we found three ground nests with two eggs, and two held black downy chicks; five pairs were defending nests but had not yet laid.

Isla Culebrita

This is the most varied and picturesque of the three larger offshore islands. It consists of three hills joined by two low sandy plains (Figure 13). The long axis, paralleling Culebra's northeast coast, is two km long, with a large mangrove-fringed lagoon on its northwestern end, a smaller lagoon and nearby swamp at its waist, and a 70-meter hill, topped by a lighthouse and heliport dominating the southeastern extension. The low waist extends northeast as a graceful crescent of dazzling white sand to a second major hill (55 m), whose northern and eastern flanks drop precipitously to the sea (Figure 13). Most of the island is covered with a dense dry scrub forest that reached a height of six to eight meters on protected leeward slopes. This merges into a distinctive and well-preserved coastal forest (Little and Wadsworth, 1964) on the isthmus.

Although land-bird density is high, Culebrita, like the two other large forested islands, is not a sea-bird island in the sense of the smaller cays, but it does shelter a small nesting colony of Red-billed Tropicbirds on its eastern cliffs (Figure 14), where we watched the courtship flight of a pair of them for an hour on 30 January. On 20 February we returned to the area and found an adult incubating its single egg. Unfortunately, future trips to the colony revealed heavy predation, including loss of adults, chicks, and eggs. In March the nest contained only shell fragments and a few remains of an adult. We searched the entire Cabo del Pasaje cliffs, finding eight nest sites, including seven adults (four dead) and an additional egg. By 15 April there was a downy chick older than 15 days, and we located a three- to four-day-old chick in a nest missed earlier. By 10 June this new chick had disappeared; the first chick, however, had survived, and was in complete juvenal plumage and nearly ready to fly. At least four adults, two eggs, and an additional chick had died. In April we put two rat traps in the colony, and each caught a black rat (*Rattus rattus*), a possible predator (Austin, 1948; Kepler, 1967); Tom Carr (pers. commun.) has seen feral cats on the island.

Cayo Botella

This small island emerges above the sea in the same reef system that encloses Culebrita, and was a major naval target. Its surface was a lumpy crater-scarred mass of loose dirt underlying concentric circles of white tires, hardly an ideal nesting habitat for sea birds; none were found. However, Botella, like Cayo del Agua, could become important for terns now that naval bombardment has ceased.

Species Accounts

Culebra, Vieques, and the extreme east coast of Puerto Rico are the western terminus for many Lesser Antillean land birds (Robertson, 1962; Lack, 1976). Some sea birds also reach the western limits of their breeding range here. The Red-billed Tropicbird, widely ranging in the Lesser Antilles, breeds on five of Culebra's offshore islands, and possibly on Cayo de Afuera, Vieques (Sorrie, 1975), but is not known to do so farther west in the Caribbean. The Common Tern, formerly known to breed in the Antilles only from the Netherlands Leeward Islands and the Virgin Islands, reaches its western breeding limit at Culebra. In contrast, Sandwich Terns breed elsewhere in the Caribbean only on a small island near Cuba's Isle of Pines. The other seven species all enjoy wide distributions in the Caribbean, and their newly discovered breeding colonies in Culebra fill gaps in our knowledge of their ranges and breeding seasons. Approximately 87,000 pairs attempted to breed in 1971 (Table 5), the bulk of them Sooty Terns on Peninsula Flamenco. Their distribution has been described for each island. In the following accounts we discuss in a general way the habitat selected and the breeding phenology for each species.

Red-billed Tropicbird

We estimated a total breeding population of about 40 pairs distributed on six islands (Table 5). Red-billed Tropicbirds preferred exposed, precipitous cliffs, although on Cayo Lobo they nested in large leeward crevices. They nest in small colonies on both large forested and isolated small cays. Even though potential nest sites were abundant and dispersed, nests were clumped; two pairs on Culebrita nested only five meters apart.

We found eggs from 20 February to 15 April, and nearly fledged young on 10 and 19 June. On islands off St. Thomas, eggs were found as early as 5 January and fledglings in April (R. Philibosian, pers. commun.), and Nichols (1943) reported nearly fledged young on 26 April. It thus appears that breeding lasts at least six months, January to June.

Predation on Culebrita (rats or cats) exceeded reproduction, and human predation on Molinos, together with rat populations on Cayo Norte and intensive habitat alteration on Lobito since this study, cause serious concern for this species in Puerto Rico.

These are the first documented breeding records for Puerto Rico, although Catesby (1743) stated that the Red-billed Tropicbird bred "in great numbers on some little islands at the east end of *Porto-Rico*" in a widely dismissed (Wetmore, 1917; Leopold, 1963), although probably accurate, record. We collected one abandoned egg from Culebrita on 13 March 1971 (USNM 41968).

White-tailed Tropicbird

On 11 April 1912, Wetmore (1917, 1927) shot three adult White-tailed

Tropicbirds near a rocky point on Cayo Luis Peña; today adults still circle the area in spring, and we found two small colonies less than four meters above sea level, the only nests we know of in the Puerto Rico area not in cliffs, and among the lowest, most accessible nests of this species found anywhere. The cliff sites on Cayos Lobo and Flamenco are more typical. Each of the 17 nests found in May was tallied in one of five mutually exclusive stages; the age of each stage is from Stonehouse (1962). Egg-laying had occurred in each month, January through mid-May, with equal frequency, and stages from eggs to juvenal plumage were found in both colonies. The breeding season extends from January through July in Puerto Rico (Danforth, 1936; Raffaele, 1973; Struthers, 1923, 1927) and the Virgin Islands (Beatty, 1941; Nichols, 1943); Culebra birds appear to fit this pattern.

Brown Booby

The 75 pairs of Brown Boobies on Cayos Geniqui, the only breeding boobies in Culebra, lie only 20 km west of a colony of more than 300 pairs on Cockroach Cay, St. Thomas (R. Philibosian, pers. commun.). The birds have persisted since Culebra's early settlement (Wetmore, 1917) in spite of human predation, probably in part because of the island's relatively remote location. We found roosting birds on Cayos Ballena and Gemelos, and on Piedra Stevens; flying birds were seen from or near most islands. Two colonies survive on limestone cays in La Cordillera, west of Cayo Lobito; with protection, some breeding birds may colonize Alcarraza.

Laying occurred in all months for which we have data, December through May, and it appeared from the helicopter that birds were incubating or had small chicks in August 1970. Elsewhere in Puerto Rico, nesting birds are found in all months, although there is a laying hiatus of one to two months at varying times between March and August on Mona and Monito Islands (Kepler, ~~in press~~ 1973).



Figure 11. Looking north to the north cay, Cayos Geniqui, from the south cay.

Laughing Gull

Nearly 650 pairs of Laughing Gulls bred on four islands in 1971 (Table 5). All colonies were on islands with relatively flat, moderately vegetated plateaus, and most nests were positioned in or near vegetation, under which the chicks scrambled soon after hatching. The forested islands, rocky cays, and bombed areas were not used; these preferences were most obvious on Cayo Geniqui, where all pairs selected sites on the vegetated northern cay while shunning its rocky neighbor. We saw no adults until April (Sorrie, 1975), with numbers greatly increasing in May; laying began late in the month, with chicks in mid-June. In June most nests contained eggs, although some were still under construction, and some downy chicks crouched in their nests among unhatched eggs; all colonies were synchronous with each other, and with colonies on Monito Island (Kepler, ~~in press~~ 1973) and off St. Thomas (R. Philibosian, pers. commun.). We saw fledglings in August (1970) and soon after, in September, most gulls depart from the West Indies (Bond, 1956), although a few overwinter each year (H. Raffaele, pers. commun.).

Although it had been assumed that Laughing Gulls bred in Puerto Rico (Leopold, 1963), the first nests were found (on Monito) in 1969 (Kepler, in press); since then, in addition to the Culebra colonies, we have located a small colony (less than 100 pairs) on rocky islets off Desecheo Island, and on one cay in La Cordillera.

Common Tern

On their two islands, Common Terns nested on barren slopes that provided relatively flat pockets of soil or debris; they avoided vertical cliffs, flat surfaces,

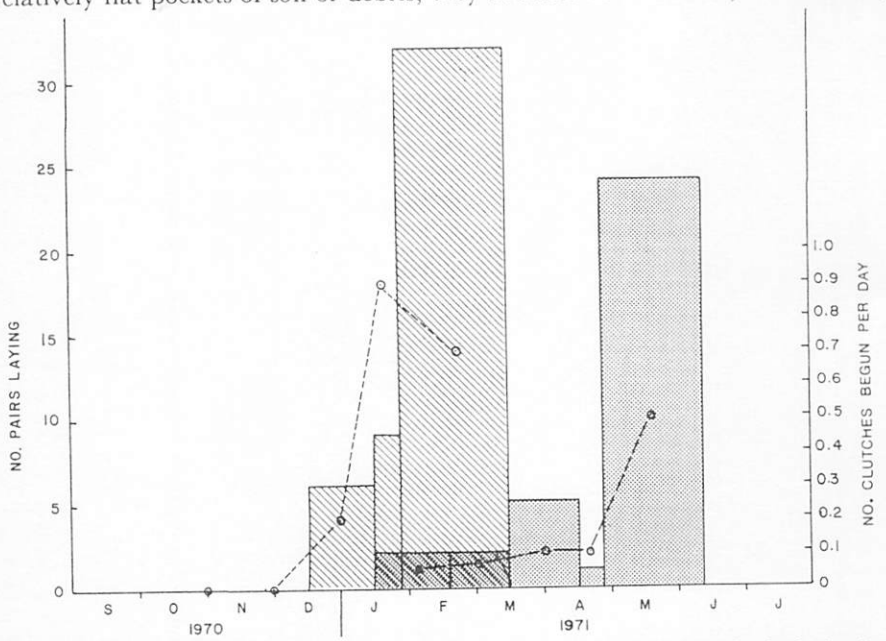


Figure 12. Brown Booby egg-laying dates, Cayos Geniqui, 1977. The number of pairs laying in a given time interval prior to our visits on 14 March (histogram, diagonals) and 10 June (histogram, dots) were determined by tallying each nest into one of the following stages (the numbers in parentheses equal age in days from laying): eggs (0–44), naked chicks (45-54), downy chicks (55-88), chicks with remiges erupting (89-114), chicks with interscapular feathers erupting (115-144), and non-flying juveniles (145–164). The line graph shows the mean number of clutches began per day for each nesting stage.

and vegetation. Both colonies were within 600 meters of bombed areas. We found mostly eggs on 19 and 20 June, with a scattering (15) of downy chicks. The same phenology was noted off St. Thomas in 1976 (R. Philibosian, pers. commun.). Incubation takes 21 days (Bent, 1921), so laying began the last of May; Nichols (1943) reported 29 May as the first egg date in the Virgin Islands. We saw our first Common Terns in June, although they arrive earlier, and they apparently remain until October (Struthers, 1923) or November (Danforth, 1931).

Bridled Tern

Bridled Terns nest virtually throughout Culebra's adjacent islands, Puerto Rico, and the West Indies. Breeding birds were found on more islands (12) than any other species, but pairs were widely dispersed, and their numbers tended to be low in any given area. In general, they occur most frequently on small cliff ledges, but we did find nests under *Coccoloba* on gently sloping limestone surfaces (Cayos Molinos) and, in one instance, under a tree at the base of a cliff only three meters above the sea (Cayo Flamenco). No birds nested on the extensive and apparently suitable cliffs of the three large forested islands; few nested on Cayo Lobo. This species is a common spring-summer resident in Puerto Rico and the Virgin Islands, laying primarily in May and June, and raising downy young in June and July (Beatty, 1941; Bowdish, 1902; Nichols, 1943; Struthers, 1927). We found only eggs on 14 May, and mostly eggs, with a few small downy chicks, from 19 to 20 June 1971.

Sooty Tern

The presence of over 170,000 breeding Sooty Terns, plus uncounted nonbreeders, provides Culebra with its unmistakable aura of a sea-bird stronghold; nowhere else in Puerto Rico do so many birds assemble. The populous colonies of White-crowned Pigeons (*Columba leucocephala*) and noisy hordes of Puerto Rican Parrots (*Amazona vittata*) are no more; only the sooties remain in vast congregations. Yet these colonies, undoubtedly present for many years, went unrecorded until 1971, and now, a scant seven years later, most of the major colony has disappeared. Without diligent protection this great spectacle could easily vanish.

The Culebra colonies differ in some respects from others (Ashmole, 1963; Robertson, 1964); birds nested under cover, as opposed to open sites (which were available), and nests were comparatively well-dispersed; both are probably responses to human predation. Like sooties in other areas, they preferred relatively level sites. The breeding season in Culebra is nearly identical to that of its similar congener, the Bridled Tern. We found only eggs in May. On 19 and 20 June we found very few young on Peninsula Flamenco, but about one third of the nests on Cayo Yerba, and nearly two thirds of those on Cayos Molinos, held downy chicks, indicating that the "main island" birds were the last to lay. The Culebra Sooty Terns lay synchronously with those at St. Thomas (Beatty, 1941; Nichols, 1943; Philibosian, pers. commun.), but about four to six weeks later than those on Monito Island, 275 km west, recalling the different laying dates between nearby colonies (17 km apart) on Manana and Moku Manu Islands, Oahu (Richardson and Fisher, 1950).

Royal Tern

Although Royal Terns are found all year in Puerto Rico, there were no

TABLE 5

Estimated Populations of Breeding Sea Birds (pairs) on Culebra and its Adjacent Islands

Location	Species: *Red-billed Tropicbird*	*White-tailed Tropicbird*	*Brown Booby*	*Laughing Gull*	*Common Tern*	*Bridled Tern*	*Sooty Tern*	*Royal Tern*	*Sandwich Tern*	*Brown Noddy*	*Total estimated pairs*
The Western Cays											
Luis Peña		20									
del Agua						50	100				
Raton					75	40				20	
Yerba	(2)*					25	18,000			100	
Lobo	10	(3)				5					
Lobito	(2)			450		30		120	700		
The Peninsula Cays											
Peninsula Flamenco							65,100				
Cayo Flamenco		(1)				15	75			25	
Cayos Molinos	5				250	40	500			150	
Piedra Stevens						*				*	
Los Gemelos						*				*	
The Northern Cays											
Cayo Matojo				80		(10)		35	35		
Cayo Norte	(10)										
Cayo Sombrerito				25		(5)				(10)	
Cayos Geniqui			75	90		140	(10)			250	
Culebrita	10										
Total estimated population (pairs)	39	24	75	645	325	360	83,785	155	735	555	86,698

* Breeding probable but not confirmed; number in parentheses is estimated population not based on nest counts.

documented breeding records previous to this study; reports of nesting on Mona (Leopold, 1963; McCandless, 1958) provide no details, and there are no other authors who mention them breeding there (H. Raffaele, 1973; Kepler, pers. observ.). Royal Terns are conspicuous all year as they fish the shallows just offshore around Culebra, and we found about 150 pairs nesting with Sandwich Terns on two islands. They preferred the edges of flat-topped, wind swept, isolated cays, and colony sites were bare or only sparsely vegetated. We found mainly eggs, some pipped, in mid-June, so laying began in late May in both colonies, roughly the same dates as reported from islands off St. Thomas (Beatty, 1941; Nichols, 1943).

Sandwich Tern

Sandwich Terns are so regularly encountered with Royals that Bent (1921) likened the two species to Damon and Pythias, legendary young Greek friends so loyal that each voluntarily faced death to save the other. The first Sandwich Terns discovered nesting in the Antilles (Montaña and Garrido, 1965) nested beside their larger congeners, as they do throughout the Gulf and Atlantic coasts. The Culebra colonies likewise were mixed, with Sandwich Terns outnumbering Royals 6:1 on Cayo Lobito, but with equal numbers on Cayo Matojo. We found only eggs on 1 June, but by 19 June there were 121 chicks (including a few Royals) and 578 eggs, many pipped, so laying began in late May, comparable to Montaña and Garrido's 24 May 1965 egg dates for the Cuban colony. Before the discovery of the Culebra colonies, Sandwich Terns were only known in Puerto Rico as winter (Danforth, 1931), spring, and fall (Leopold, 1963) visitors, birds that are possibly locally dispersed Culebra residents.

Every bird closely observed (in excess of 100) was morphologically typical of the northern race, *Sterna sandvicensis acuflavida*, which has a solid black bill tipped with yellow. We saw no birds with mottled black and yellow, or almost entirely



Figure 13. Looking west at Cabo del Pasaje, and Red-billed Tropicbird nesting cliffs (arrow), Isla Culebrita, with Cabeza de Perro (Culebra) and Cayo Pela in the background.

breeding probable but not confirmed; number in parentheses is estimated population not based on nest counts.

yellow, bills, suggesting a lack of genetic contact with the more southerly race, *S. s. eurygnatha.*

Brown Noddy

Brown Noddies, like Bridled Terns, prefer steep cliffs as nest sites. They avoided the large forested island, and were also absent from Cayo Lobo, Lobito, del Agua, and Matojo, where Bridled Terns nested. Their absence from the latter two islands probably resulted from a lack of high cliffs, but it is hard to understand why no Noddy Terns nested on Cayo Lobito. With the exception of two stick nests in trees (Cayos Geniqui), all nests were on pockets or ledges on cliffs. We found no birds in April, only eggs in May, eggs or small downy chicks (few) in mid-June, and some birds still on their cliffs in August. Bowdish (1902) recorded some well-grown young in late June, for the earliest laying records (mid-April); all other authors indicated eggs in May or June, as we found in Culebra. Although birds may be found in any month around Puerto Rico (Leopold, 1963), most leave the region in September, returning again in April (Nichols, 1943).

Non-breeding Birds

We recorded four species that apparently did not breed in Culebra's waters, but all are resident elsewhere in Puerto Rico and the Virgin Islands, and with the possible exception of the Brown Pelican, were probably transients. Small numbers (fewer than five) of Magnificent Frigatebirds regularly soared over most islands, and a single bird once roosted on Cayo Ballena. We could always expect Brown Pelicans offshore; more than 20 roosted on Luis Peña on 13 May, and one roosted on Cayo Pela in August 1970. Likely sources for the Culebra birds are colonies on Cayo Conejo, Vieques (Sorrie, 1975), 19 km west, and Dutchcap Cay, 20 km east. It is possible that a small pelican colony remains undiscovered in the extensive mangroves along the Puerto de Manglar shore, which we did not study.

On 16 April, three Gull-billed Terns (*Gelochelidon nilotica)* flew by Culebrita, and in May and June we saw small numbers (fewer than four) of Roseate Terns (*Sterna dougallii*) fly by and roost on Cayos Molinos and several western cays, perhaps attracted by the Common Terns that nested there.

Discussion

Culebra's islands can be grouped by the diversity of birds using them. Storm-tossed, low cays such as Ballena and Tiburon are important roosts, but harbored no breeding birds. The heavily-bombed islands (del Agua, Alcarraza, and Botello) were also depauperate, although terns attempted to nest, and they could become productive areas. The only impact area colonized was Peninsula Flamenco, but the greatest nest densities were in untargeted areas (Figure 9). Islands next to active targets (Raton, Yerba, Molinos, and Flamenco) harbored good populations of terns, but were not used by gulls, even though vegetation appeared suitable on all except Cayo Raton, suggesting that range use was adversely affecting them. Only tropicbirds used the large forested islands, and they restricted their activity to the barren cliffs and shores. Although Cayo Lobo had only a small forest patch, it was nearly devoid of sea birds, and more closely resembled the forested islands in bird composition. Islands with the most diverse colonies (Lobito, Matojo, and Geniqui) shared a single important characteristic: they were farthest from military activity and the town of Dewey. Demonstrating the importance of isolation, Royal Terns, known to be

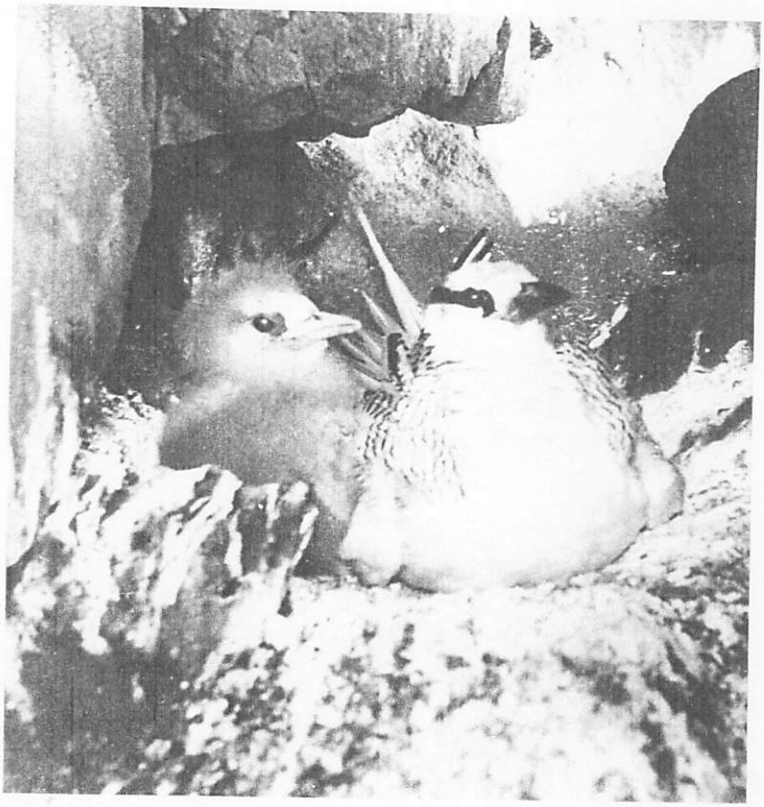


Figure 14. Adult Red-billed Tropicbird with downy chick, Isla Culebrita, 13 March 1971.

intolerant of repeated disturbance (Buckley and Buckley, 1972), were restricted to two of these islands. In other features, however, the islands are vastly different; Lobito and the north cay of Geniqui are high and densely vegetated, Matojo is low, flat, and sparsely vegetated, and close to Culebra, and the south cay of Geniqui is high and largely barren.

Even though Peninsula Flamenco and most of Culebra's islands were set aside as a bird reserve in 1909, there has never been a published account of what birds were protected. How could such impressive colonies exist without attracting scientific attention? The answer lies in their relative isolation, the months in which naturalists searched the area, and constraints imposed by the U.S. Navy. With the exception of the Brown Booby, all breeding sea bird species are either larids resident only from May through August, or dispersed, relatively uncommon tropicbirds with concealed nests. A. Baker and J. Milligan made the first bird collections on Culebra from 7 to 12 February 1899, well before the larids returned. Wetmore (1917) collected from 4 to 12 April 1912, and although he visited Luis Peña and Culebrita, and sailed close to Cayo Lobo, he also was too early for the larids, and missed the pelecaniform nests. Danforth (1935) spent 10 days on Culebra and Cayo Norte from 25 December 1935 to 4 January 1936, and Heatwole et al. (1963) were on Culebra from 7 to 12 November 1962, again dates well outside the major breeding season. The next surveys were ours, and in October 1968 we learned of the colonies only through rumors of egging by Dewey residents, and accounts of the Sooty Terns on Peninsula Flamenco by Ricardo

Cotte, our companion for the trip. The fact that all colonies were closed by the U.S. Navy must have discouraged potential expeditions by other naturalists.

The Navy left the islands in 1975, and since then their fate has been the concern of the U.S. Fish and Wildlife Service, the Puerto Rican Department of Natural Resources, other conservation agencies (see *Auk*, 94:130-131), and developers. Present plans call for the inclusion of all the islands discussed in this paper, except Caro Norte, in a national wildlife refuge. In addition, the distal half of Peninsula Flamenco, part of Mt. Resaca, Cayo Pela, and the mangrove shores of Puerto del Manglar are considered seriously for inclusion in the refuge, which would provide protection for one of the most striking concentrations of birds in the West Indies. Without protection, the rising pressures of urbanization, resort development, grazing, and the taking of eggs and young would be far more destructive than naval bombardment, and would undoubtedly relegate this impressive spectacle to the dusty reports of naturalists fortunate enough to have visited the colonies before they were lost.

Summary

Peninsula Flamenco, a prominent northern extension of Culebra, and 13 offshore islands, all within a former naval target area, were used as breeding grounds in 1971 by approximately 87,000 pairs of sea birds of 10 species. None of these birds had been reported breeding in the area before this study; four of them (Red-billed Tropicbird, Common Tern, Royal Tern, and Sandwich Tern) are new breeding records for Puerto Rico, and the Sandwich Tern colonies are only the second and third known in the West Indies. West Indian populations of the Red-billed Tropicbird and Common Tern reach their western limits as breeding species at Culebra, and the sea bird fauna, including two tropicbirds, Brown Booby, Laughing Gull, and six species of terns, is similar to that in the Virgin Islands. With the exception of the Sooty Tern, the breeding phenology of each species is synchronous with colonies elsewhere in Puerto Rico and the Virgin Islands. Sooty Terns in Culebra breed four to six weeks later than birds on Monito Island, 275 km west, but are synchronous with colonies off St. Thomas. Sea bird diversity is greatest on islands farthest from human disturbance, and is depressed on islands that are heavily vegetated, bombed, or awash in stormy weather. Unbombed islands near active targets held large colonies with fewer species.

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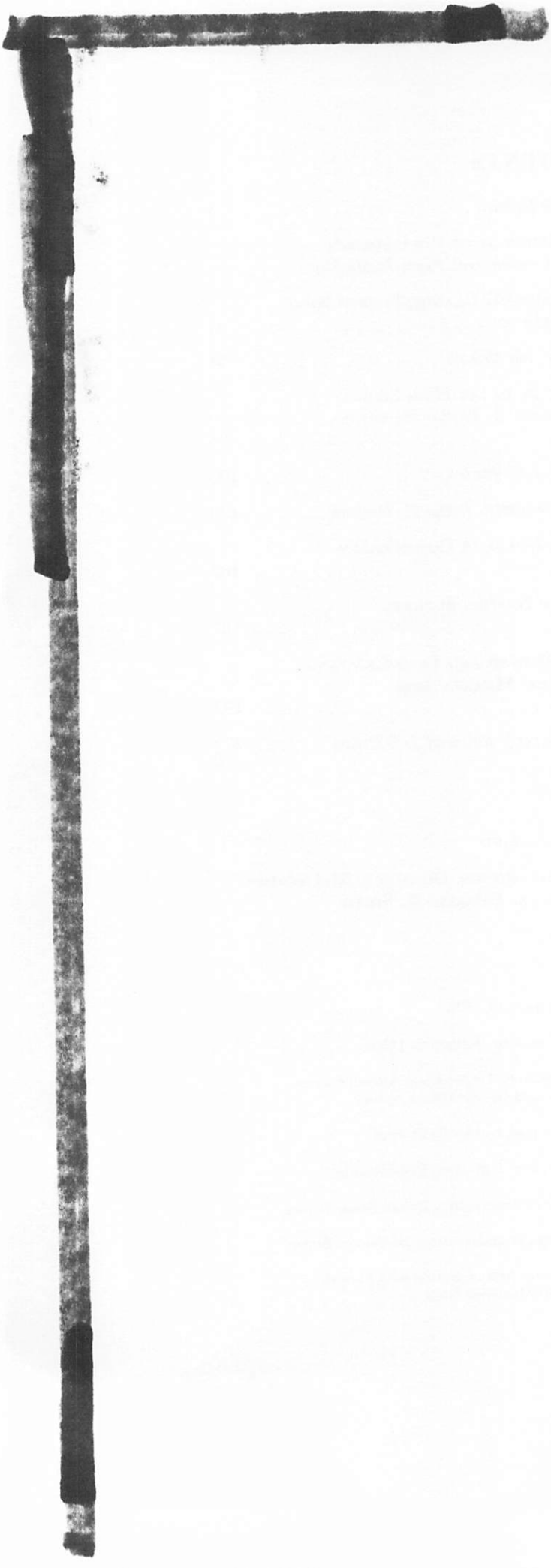
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CORRECTIONS FOR *THE LIVING BIRD*
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Page 28, Figure 4, caption: change "northwest to (right to left)" to "northeast to (left to right)."

Page 30, Figure 6: delete "(arrow)" from caption.

Page 32, Figure 7: The figure has been turned 90° clockwise. View it from the outer edge of the page.

Page 32, paragraph 2, line 7: change "Kepler, in press)" to "(Kepler, 1978)."

Page 30, paragraph 3, lines 4 and 5: change "(Kepler, in press)" to "(Kepler, 1978)."

Page 41, paragraph 3, line 5: change "(Kepler, in press)" to "(Kepler, 1978)."

Page 42, paragraph 1, line 12: "(Kepler, in press)" should read "(Kepler, 1978)."

Page 50, author's address: "Kawed" should read "Kaweo."

Page 137, paragraph 1, line 7: "conclvely" should read "conclusively."

Page 142, paragraph 5, line 1: "Slender-billed Nutcracker" should read "Slender-billed Nutcracker (*N.c. macrorhynchos*)."

Page 145, paragraph 4, line 9 should read: "Sutton and Amann (1953) and Reimers (1958) reported that Slender-billed Nutcrackers transported seed as far as 10 to 12 km and 15 km, respectively."